

85 12 105  
SB761  
U7R6  
#84-8  
c.1

# FOREST PEST MANAGEMENT

BIOLOGICAL EVALUATION R2-84-78

Mountain Pine Beetle  
in the Black Hills of  
South Dakota and Wyoming

1984



United States  
Department of  
Agriculture

Forest Service

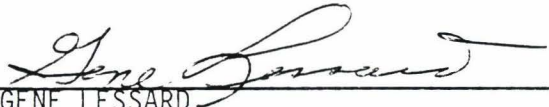
Forest Pest Management  
Denver, Colorado

BIOLOGICAL EVALUATION R2-84-7

Mountain Pine Beetle  
in the Black Hills of  
South Dakota and Wyoming

1984

PREPARED BY:

  
GENE LESSARD  
Entomologist

REVIEWED AND RECOMMENDED BY:

  
ROBERT D. AVERILL  
Group Leader, Entomology

Approved by:

  
JAMES R. BEAVERS  
Director, Timber, Forest Pest, and  
Cooperative Forestry Management

Timber, Forest Pest, and  
Cooperative Forestry Management  
USDA Forest Service  
Rocky Mountain Region  
11177 West 8th Avenue  
Lakewood, Colorado 80225

LIBRARY

JUN 13 1985

ROCKY MOUNTAIN STATION

## INTRODUCTION

Historically, mountain pine beetle, Dendroctonus ponderosae Hopk., has caused extensive mortality in ponderosa pine in the Black Hills of South Dakota and Wyoming. Infestations and suppression efforts from 1895 to 1974 are well documented (Thompson 1975). On average, infestations occurred on an 11 year cycle (9.3 infestations per 100 years). On about a 37 year cycle (2.7 infestations per 100 years) infestations caused a high level of tree mortality similar to the infestations of 1900, 1940 and 1974.

The pattern of infestation, generally, is the same for each infestation. Scattered trees are first detected in the high elevation areas around Warren Peak in Wyoming, the Exemption Area in the Northern Hills of South Dakota and Harney Peak in the Southern Hills of South Dakota. As infestation increases, groups of trees are killed and the infestation increases in extent primarily on the Limestone Plateau. During most infestations (9.3/100 yrs) the process reverses back to scattered trees at high elevations. Under the extremes (2.7/100 yrs) groups of infested trees coalesce into larger groups and infestation occurs in the low elevation Crystalline Basin.

Again, as the infestation subsides the process is reversed. Not all infestations reverse to scattered endemic levels. Some infestations increase from endemic levels to a peak, reverse part way back to endemic and reverse again to a new peak.

Over an extensive area such as the Black Hills, an infestation is, in reality, a composite of infestations occurring at the stand level. The duration and intensity of infestation in the stand is directly related to stand structure (Lessard 1982) and is a function of the number of trees in the stand between 7.1-13.0 inches dbh and stand size. Generally, even-aged stands are more susceptible than uneven-aged stands.

A number of factors predispose individual trees to attack by mountain pine beetle. Of primary importance in the Black Hills is *Armillaria* root rot (Hinds, et al. 1984; Lessard, et al. in press).

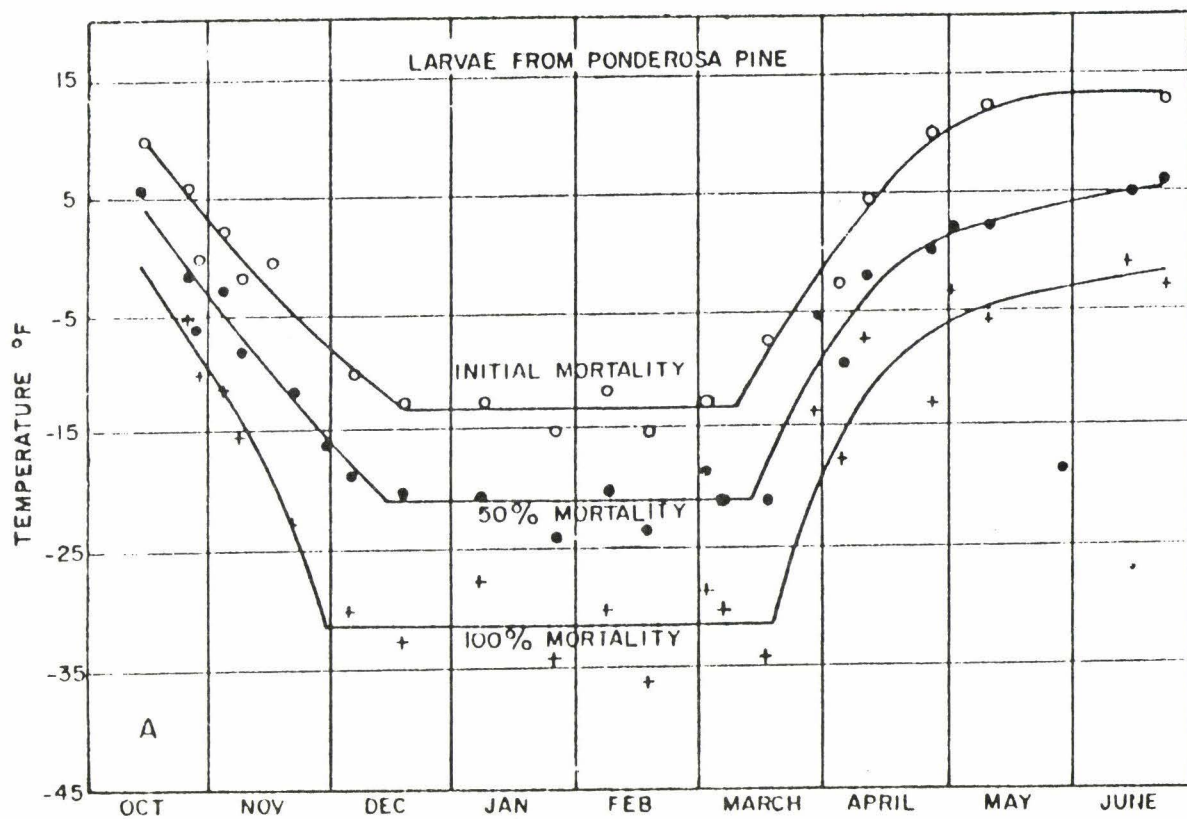
There are a number of biotic and abiotic factors which control mountain pine beetle populations. Predators and parasites put continuing pressure on mountain pine beetle. Schmid (1968) noted that "The beetle population generally decreases by at least 50% between August and the following May." The two primary predators of Mountain Pine Beetle in the Black Hills are a fly, Medaterra aldrichii, and a Beetle, Enoclerus sphegeus (Schmid 1971; Schmid 1970). However, peaks in predator-parasite populations often lag behind peaks in Mountain Pine Beetle populations by 2 or more years. Climatic factors, on the other hand, can have an instantaneous effect on beetle populations. Low temperatures during the flight period can inhibit flight and mating. The threshold temperature is about 65°F (McCambridge, 1971). The threshold for larval development is between 36°F and 40°F (2.2°C and 4.4°C) (McCambridge 1974). Ambient temperatures would have to be

substantially lower than 36-40°F to produce these subcortical temperatures. Larval mortality due to extremes in low temperatures have been reported for spruce beetle (Massey and Wygant 1954; Terrel 1954; Frye, et al. 1974). However, this relationship has not been reported for mountain pine beetle. Prolonged ambient temperatures of -40 to -70°F were required to kill spruce beetle larvae. Frye, et al., (1974) noted that "cold temperatures in fall or winter months, before beetles develop 'cold hardiness' have appeared to be most effective in reducing beetle populations." Unpublished data on mountain pine beetle larval mortality and temperature are displayed in Figure 1 <sup>1/</sup>. Note that "cold hardiness" increases from mid-October to mid-December, levels off from mid-December to mid-March and, decreases from mid-March to June.

---

<sup>1/</sup> Unpublished data collected by Wygant and summarized by McCambridge.

FIGURE 1 - MOUNTAIN PINE BEETLE LARVAL MORTALITY  
AS A FUNCTION OF TEMPERATURE



The objectives of this evaluation are:

- 1) To summarize the latest infestation in the Black Hills (1969-1984)
- 2) To discuss possible causes of the 1984-85 infestation decline.
- 3) To predict future trends of the Mountain Pine Beetle.
- 4) To update strategies for Mountain Pine Beetle prevention and suppression.

#### METHODS

To summarize the latest infestation trend in the Black Hills, records from annual aerial reconnaissance flights were reviewed. During these flights mountain pine beetle caused mortality is mapped for both location and the number of trees killed at that location. Since about 9 months are required for a tree to fade and be visible from the air, the mortality mapped in any one year represents the infestation for the previous year.

If the flight is timed properly, 2 past years of infestation can be detected based on the color of the foliage. However, tree fading is highly variable between years and separation of trees by year of infestation is often subjective. Also, trees fade at differential rates. Therefore, estimates of mortality are often lower than actual mortality.

To obtain a picture of the relative infestation trend, a 3-year running average of infested trees is used in this evaluation.

To estimate the 1984 infestation sample plots were established at 18 locations in six geographic areas in the Black Hills of South Dakota and Wyoming (Figure 2):

| Location                   | No. of<br>Plots |
|----------------------------|-----------------|
| Northern Bearlodge Mts.    | 4               |
| Southern Bearlodge Mts.    | 4               |
| Cement Ridge               | 3               |
| Northern Limestone Plateau | 3               |
| Custer Peak                | 2               |
| Copper Mtn.                | 2               |

At each location two 40 chain long by one chain wide strip cruises were established. Each strip was subdivided into 10 chain long subplots. On each subplot all 1982, 1983 and 1984 infested trees were tallied. A 10-BAF variable plot was established at the beginning and end of each strip and at 10-chain intervals along each strip. All "in" trees were tallied.

A map of the Black Hills National Forest area, spanning South Dakota and Wyoming. The map shows the forest boundary as a thick black outline. Numerous towns are labeled with dots: ALBANY, SIOUX FALLS, DEADWOOD, TERRY, RAPID CITY, SPOONER, LARIMORE, CODY, CHEYENNE, ROCKWELL, SHERIDAN, WYOMING, HILL CITY, MT. PLEASANT, MT. VERNON, MINERSVILLE, COSTCO, STATE PARK, WOOD CAVE NATIONAL MONUMENT, PENNSLAND, BENTLEY, and RENO. Survey locations are indicated by upward-pointing arrows. A legend at the bottom left includes a scale bar from 0 to 10 miles and the title "BLACK HILLS NATIONAL FOREST SOUTH DAKOTA--WYOMING". A note at the top right states "Survey Locations" next to an arrow symbol. A dashed box outlines the "WIND CAVE NATL. MON.", and another dashed box outlines the "COSTCO STATE PARK".

Multiple regression equations were used to estimate percent stand loss (Lessard 1982). These equations are:

1. Increasing and decreasing population trend.

$$t = -0.19 + 7.22x + 3.39y + 10.36 z$$

where:

t = expected percent infestation

x = P<sub>7.1-11.0</sub>; proportion of green trees in the 7.1-11.0 inch diameter class to a 3.1 inch minimum

y = P<sub>11.1-15.0</sub>; proportion of green trees in the 11.1-15.0 inch diameter class to a 3.1 inch minimum

z = P<sub>15.1-19.0</sub>; proportion of green trees in the 15.1-19.0 inch diameter class to a 3.1 inch minimum

2. Epidemic population

$$t = 21.15 - 61.53x + 113.76y - 59.06z$$

where:

t = expected percent infestation

x = P<sub>7.1-9.0</sub>; proportion of green trees in the 7.1-9.0 inch diameter class to a 3.1 inch minimum

y = P<sub>9.1-11.0</sub>; proportion of green trees in the 9.1-11.0 inch diameter class to a 3.1 inch minimum

z = P<sub>11.1-13.0</sub>; proportion of green trees in the 11.1-13.0 inch diameter class to a 3.1 inch minimum

## RESULTS AND DISCUSSION

Infestation history--The 14-year outbreak cycle is graphically illustrated in Figure 3. Estimators of total infested trees indicate low level populations from 1967 to 1969 (Table 1). The infestation level increased 7-fold from 1970 to 1974. The rate of increase during this period was 157,800 trees/year. From 1974 to 1983 a steady decline occurred to the low levels of the late 1960's. The rate of decrease during this period was 87,000 trees/year. From 1969 to 1983 an estimated 4.3 million trees were lost to the mountain pine beetle. This equates to a volume loss of 202 MMBF<sup>1/</sup>. This volume loss is equivalent to total annual volume growth on the Black Hills National Forest (200 MMBF/year).

---

<sup>1/</sup> Volume loss calculated from an average 10 inch diameter tree at 60 foot height--BD FT volume Scribner to an eight inch top (Myers 1964).

FIGURE 3 - MOUNTAIN PINE BEETLE INFESTATION CYCLE IN  
THE BLACK HILLS - 1969 to 1983

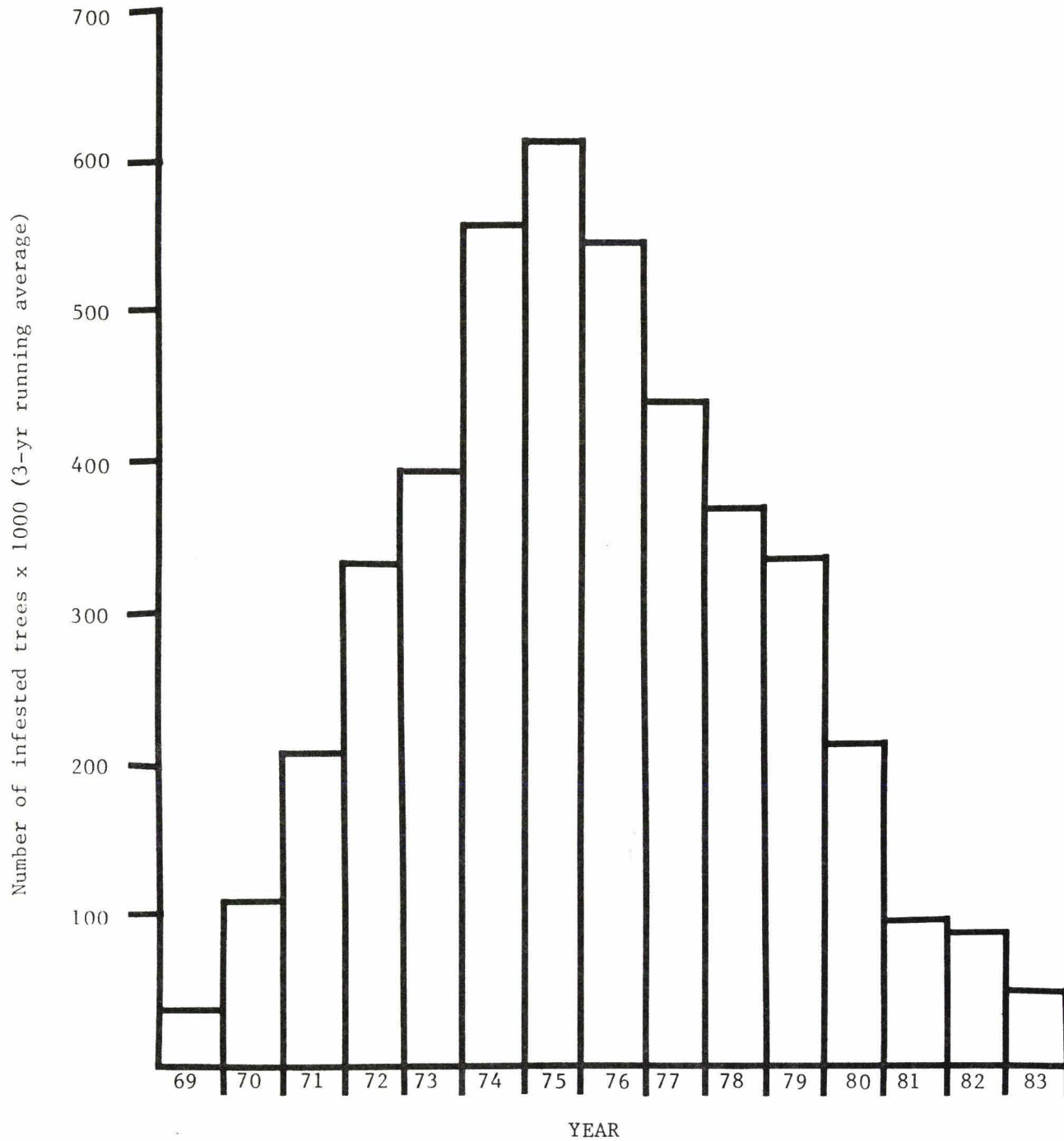


TABLE 1--Estimated Mountain Pine Beetle Infested Trees, Black Hills  
from 1967-1983. (From annual aerial reconnaissance surveys)

| YEAR  | TOTAL<br>INFESTED TREES<br>x1000 | 3-YEAR<br>RUNNING AVERAGE<br>x1000 |
|-------|----------------------------------|------------------------------------|
| 1967  | 46                               |                                    |
| 1968  | 40                               |                                    |
| 1969  | 30                               | 39                                 |
| 1970  | 255                              | 108                                |
| 1971  | 335                              | 207                                |
| 1972  | 420                              | 337                                |
| 1973  | 435                              | 397                                |
| 1974  | 819                              | 558                                |
| 1975  | 587                              | 614                                |
| 1976  | 230                              | 545                                |
| 1977  | 500                              | 439                                |
| 1978  | 380                              | 370                                |
| 1979  | 135                              | 338                                |
| 1980  | 135                              | 217                                |
| 1981  | 20                               | 97                                 |
| 1982  | 103                              | 86                                 |
| 1983  | <u>28</u>                        | 50                                 |
| TOTAL | 4,412                            |                                    |

Table 2 displays trees per acre attacked for each of the 6 geographic areas sampled. In each geographic area beetle populations decreased from 1983 to 1984. Mean trees per acre infested in 1984 ranged from zero for the Copper Mountain area to 0.59 for the Southern Bearlodge Mtns area. Of the 18 locations sampled, only 2 showed an increasing population from 1983 to 1984. These 2 locations are Cook Lake, Northern Bearlodge Mts (2.0:1) and Citadel Rock, Northern Limestone Plateau (2.5:1). The dramatic decline in population could be the result of subnormal temperatures in December 1983 (Figure 4). The average temperature for December 1983 was 10.0°F. (This was 16.0°F below normal.) Average temperatures in the Black Hills were below those required to produce larval mortality for 9 consecutive days (12/17-25) and, below those required to produce 50% population reduction for 5 consecutive days (12/20-24).

TABLE 2--Trees/acre attacked and attack ratios for sample locations in the Black Hills of South Dakota & Wyoming, 1984.

| Geographic Area              | Location              | Pitch |       |      |      |        |        |
|------------------------------|-----------------------|-------|-------|------|------|--------|--------|
|                              |                       | 1984  | 1983  | 1982 | Out  | 84:83  | 83:82  |
| Northern Bearlodge Mountains | Williams Spring       | 0.12  | 0.12  |      | 0.12 | 1.00:1 |        |
|                              | Merrick Spring        |       |       |      | 0.37 |        |        |
|                              | Cook Lake             | 0.25  | 0.12  | 0.37 | 0.25 | 2.0:1  | 0.32:1 |
|                              | 830 Road              | 0.25  | 1.50  | 0.50 | 0.12 | 0.17:1 | 3.00:1 |
|                              | Mean                  | 0.16  | 0.44  | 0.22 | 0.22 | 0.36:1 | 2.00:1 |
| Southern Bearlodge Mountains | Whitelaw Creek        | 1.12  | 3.75  | 4.87 | 1.37 | 0.30:1 | 0.77:1 |
|                              | Warren Peak (State)   | 0.62  | 4.25  | 2.00 | 1.75 | 0.15:1 | 2.12:1 |
|                              | Warren Peak           | 0.62  | 24.50 | 5.75 | 1.37 | 0.20:1 | 4.26:1 |
|                              | Krusee Canyon (State) |       |       | 0.12 | 0.25 |        |        |
|                              | Mean                  | 0.59  | 8.12  | 3.19 | 1.19 | 0.07:1 | 2.54:1 |
| Cement Ridge                 | Bull Hill             | 0.25  | 0.25  | 0.75 |      | 1.00:1 | 0.33:1 |
|                              | Katan Spring          |       |       | 0.12 | 0.12 |        |        |
|                              | Cement Ridge          |       | 0.12  |      | 0.12 |        |        |
|                              | Mean                  | 0.08  | 0.12  | 0.29 | 0.08 | 0.67:1 | 0.41:1 |
| Northern Limestone Plateau   | Citadel Rock          | 1.25  | 0.50  | 3.37 | 1.37 | 2.50:1 | 0.15:1 |
|                              | Timber Gulch          |       | 0.37  | 0.12 | 0.12 |        | 3.00:1 |
|                              | Little Spearfish      | 0.37  | 6.87  | 4.87 | 0.50 | 0.05:1 | 1.41:1 |
|                              | Mean                  | 0.54  | 2.58  | 2.79 | 0.66 | 0.21:1 | 0.92:1 |
| Custer Peak                  | Custer Peak           |       | 0.37  | 0.12 |      |        | 3.00:1 |
|                              | Custer Crossing       | 0.12  |       |      | 0.12 |        |        |
|                              | Mean                  | 0.06  | 0.19  | 0.06 | 0.06 | 0.32:1 | 3.17:1 |
| Copper Mountain              | Long Draw             |       |       |      | 0.12 |        |        |
|                              | Copper Mountain       |       |       |      |      |        |        |
|                              | Mean                  |       |       |      | 0.06 |        |        |

FIGURE 4 - MINIMUM TEMPERATURE (F°) FOR DECEMBER 1983 IN RELATION TO MOUNTAIN PINE BEETLE LARVAL MORTALITY IN PONDEROSA PINE

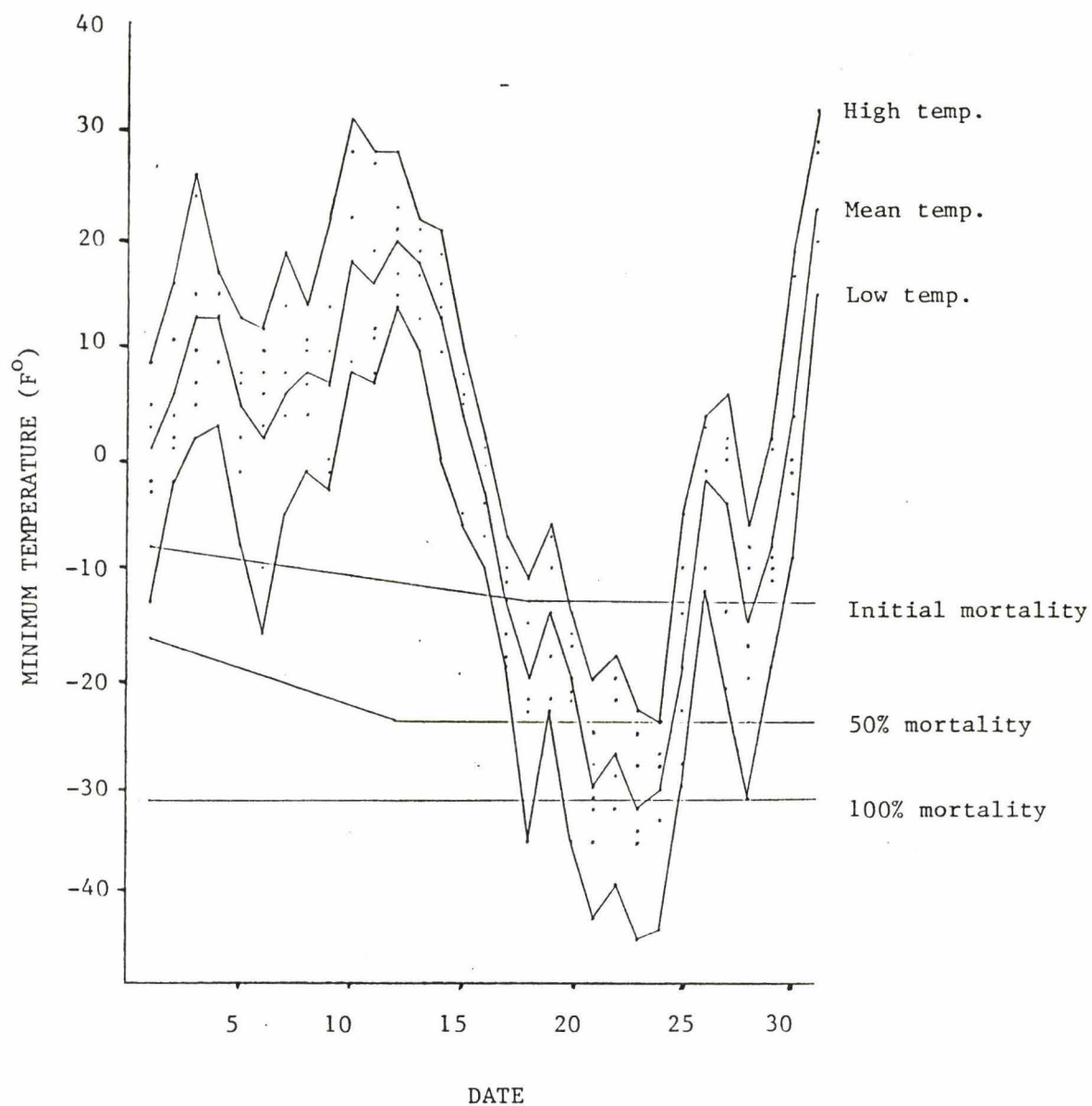


Table 3 displays trees per acre in the residual green stand(s) at each location and predicted mountain pine beetle caused mortality over the next infestation period. The level of tree mortality is a function of stand structure and the level of stocking in susceptible trees. Predicted losses range from 17.4 trees per acre (29.8%) in the Custer Peak area to 87.1 trees per acre (27.8%) in the northern Limestone Plateau area.

Infestation periodicity and intensity should change due to forest management practices. As stands become less susceptible to MPB the period between infestations should increase and the intensity (trees per acre) should decrease.

TABLE 3--Stocking Levels and Predicted Mortality for Sample Locations in the Black Hills of South Dakota and Wyoming.

| Geographic Area              | Location              | Trees per Acre |                         |                                 |
|------------------------------|-----------------------|----------------|-------------------------|---------------------------------|
|                              |                       | Residual Green | Predicted MPB Mortality | Predicted Percent MPB Mortality |
| Northern Bearlodge Mountains | Williams Spring       | 45.4           | 6.3                     | 13.9                            |
|                              | Merrick Spring        | 80.4           | 20.4                    | 25.4                            |
|                              | Cook Lake             | 75.5           | 20.7                    | 27.4                            |
|                              | 830 Road              | 48.2           | 24.4                    | 50.6                            |
|                              | Mean                  | 62.3           | 17.7                    | 28.4                            |
| Southern Bearlodge Mountains | Whitelaw Creek        | 184.7          | 53.4                    | 28.9                            |
|                              | Warren Peak (State)   | 125.5          | 42.8                    | 34.1                            |
|                              | Warren Peak           | 271.3          | 91.7                    | 33.8                            |
|                              | Krusee Canyon (State) | 149.8          | 66.0                    | 44.1                            |
|                              | Mean                  | 182.8          | 61.4                    | 33.6                            |
| Cement Ridge                 | Bull Hill             | 141.0          | 39.1                    | 27.7                            |
|                              | Katan Spring          | 131.9          | 31.8                    | 27.7                            |
|                              | Cement Ridge          | 47.9           | 12.7                    | 25.9                            |
|                              | Mean                  | 106.9          | 27.7                    | 25.9                            |
| Northern Limestone Plateau   | Citadel Rock          | 354.1          | 123.9                   | 35.0                            |
|                              | Timber Gulch          | 292.9          | 65.0                    | 22.2                            |
|                              | Little Spearfish      | 293.6          | 83.6                    | 28.5                            |
|                              | Mean                  | 313.5          | 87.1                    | 27.9                            |
| Custer Peak                  | Custer Peak           | 59.3           | 19.5                    | 32.9                            |
|                              | Custer Crossing       | 57.5           | 16.3                    | 28.3                            |
|                              | Mean                  | 58.4           | 17.4                    | 29.8                            |
| Copper Mountain              | Long Draw             | 140.9          | 25.5                    | 18.1                            |
|                              | Copper Mountain       | 364.3          | 77.8                    | 21.3                            |
|                              | Mean                  | 252.6          | 50.5                    | 20.0                            |

Using decision analysis, a procedure was developed to match management strategy to a land classification system (Freeling and Seaver, 1980). The procedure first develops a land classification system based on the following criteria:

1. Risk to mountain pine beetle (MPB) infestation
2. Land accessibility (and/or operability)
3. Tree value

The eight land classification categories developed were:

- A. Moderate to high MPB risk  
Accessible  
High individual tree value
- B. Moderate to high MPB risk  
Accessible  
Low individual tree value
- C. Moderate to high MPB risk  
Inaccessible  
High individual tree value
- D. Moderate to high MPB risk  
Inaccessible  
Low individual tree value
- E. Low risk to MPB  
Accessible  
High individual tree value
- F. Low risk to MPB  
Accessible  
Low individual tree value

G. Low risk to MPB  
Inaccessible  
High individual tree value

H. Low risk to MPB  
Inaccessible  
Low individual tree value

The criteria used to develop the land classification system are qualitative. However, each can be quantified. Since this is a dynamic classification scheme, it will need to be updated to keep pace with tree growth (risk), improved harvesting technology, and changing land use values.

Accessibility - Accessibility implies operability. Both accessibility and operability vary with the management strategy selected and the equipment available to implement the strategy. As an example, slopes in excess of 40% may be inoperable to conventional logging equipment but operable for a high lead system; or, operable for chemical pesticide application.

Tree Value - Value systems are highly variable and often difficult to quantify. The goals and objectives established for an area determine the value system (s) to be used (i.e., recreation and aesthetics, wildlife habitat, wood fiber, etc.). Thus, a given piece of land and tree resource will have a value affected by tree density, and quality, and land use. Effects of the mountain pine beetle may enhance or detract from that value. The objective is to minimize the loss of the resource value from mountain pine beetle through the application of one or more strategies. For mountain pine beetle there are three preventive strategies:

1. Thinning of stands
2. Preventative spraying
3. Favoring tree species other than the host species and one suppression strategy:
  - a. Direct control-actions taken to reduce the population immediately.

Inherent in these management strategies is their applicability, or more properly, their nonapplicability on some land classifications. As an example, direct chemical treatment of low risk, low value trees over large inaccessible areas would be inefficient economically and therefore inappropriate.

Five major premises were developed using decision analysis (Freeling and Seaver, 1980):

1. All host type, regardless of ownership can be stratified into land classification units.
2. Mountain pine beetle cannot be suppressed by any method over extensive areas of land.
3. Management and suppression of MPB is viable in restricted areas of type having relatively high value.
4. The ideal strategy for managing mountain pine beetle is to intensively manage the host type, thereby preventing outbreaks from occurring.
5. Prevention is a viable strategy only in moderate to high susceptible stands or in low susceptible stands which will be in a moderate to high susceptible condition in the near future.

Failure to recognize these premises will lead to failure for any long range management of mountain pine beetle.

Management opportunities identified in the decision analysis process (Freeling and Seaver 1980) were:

1. Incorporate into Forest plans management prescriptions for the major insects and diseases causing tree damage in the Region.
2. Involve State and local governments to a greater degree in future planning efforts.
3. In cooperation with Federal, State and local governments and private landowners implement a management program to prevent and suppress the mountain pine beetle on all lands in land classification A, B, C, and E using the following recommended strategies.

Land Classification A - On developed recreation areas where mountain pine beetle is present, the preferred strategy is to suppress the insect by harvesting infested trees before beetle flight. On developed recreation areas where an epidemic has run its course, the preferred strategy is to do nothing. If an epidemic has not yet occurred, thinning is recommended. This reduces the susceptibility of the area to mountain pine beetle.

On type A areas other than developed recreation sites the preferred strategy is thinning for prevention, or harvesting of infested trees. In areas where the beetle is already epidemic, the preferred strategy is dependent upon tree value and recreation values. If the recreational value is greater than about six times the stumpage value (acre basis), then suppression is best. With lower recreation values, however, thinning is the preferred strategy. In areas where the beetle is either not present, or inactive, thinning is preferred as thinning may prevent

beetle epidemics. In particular, immediate thinning is much preferred to waiting for an epidemic to start and then thin. Thorough analysis of the benefits and costs of the various tactics in relation to the value of the management objectives will aid in development of the preferred approach to suppression in a given situation.

Land Classification B - In these areas a thinning program is the preferred strategy. This is due largely to the beneficial silvicultural effects and reduced detrimental recreation effects.

Land Classification C - In these areas where thinning is impractical due to constraints on accessibility and operability, suppression by chemical means is considered the best strategy under epidemic conditions. However, this strategy is only marginally superior to doing nothing and accepting the losses.

Land Classification E - On these low MPB susceptibility areas, harvesting infested trees is the preferred strategy. Because these are high value lands, this strategy is effective in reducing the impacts on scenic, recreational and real-estate value.

In summary, the greatest benefit appears to be from thinning programs in those highly susceptible areas where beetles are not present, but there is also some net benefit from continuing with suppression efforts in those higher value areas where beetles are present.

4. On land classification areas D, F, G, and H allow the mountain pine beetle to run its course.

5. Initiate and maintain a continuous program of unified management on all lands.

The greatest opportunity to reduce the impact from the MPB in the Black Hills is currently on slopes previously considered inoperable to available logging equipment. Uneven-aged stand management may be preferable in these areas particularly if re-entry is not scheduled in the near future (ca. 40 years). "Uneven aged stands are less likely to sustain a mountain pine beetle epidemic than even-aged stands. If an epidemic does occur in an uneven-aged stand, losses to the mountain pine beetle will be in the order of 30-50% less than the most susceptible even-aged stand with comparable stocking (Lessard, 1982)."

## LITERATURE CITED

- Freeling, Anthony N. S. and D. A. Seaver. 1980. Decision analysis in Forest Service planning: treatment of mountain pine beetle. Decision Science Consortium, Inc. Tech. Rept. 80-8. 93 pp.
- Frye, R. H., H. W. Flake and C. J. Germain. 1974. Spruce beetle winter mortality resulting from record low temperatures in Arizona. *Env. Entomol.* 3:752-4.
- Hinds, T. E., L. R. Fuller, E. D. Lessard, and D. W. Johnson, 1984. Mountain pine beetle infestation and armilaria root disease of ponderosa pine in the Black Hills of South Dakota. USDA For. Serv. Tech. Rept. R2-30.
- Lessard, Gene. 1982. Factors affecting ponderosa pine stand susceptibility to mountain pine beetle in the Black Hills - 1981. USDA For. Serv. Tech. Rept. R2-26, 16 pp.
- Lessard, Gene, D. W. Johnson, T. Hinds and W. H. Hoskins. (In Press). Association of root disease with mountain pine beetle infestations on the Black Hills National Forest, South Dakota. USDA For. Serv.
- Massey, C. L. and N. D. Wygant. 1954. Biology and control of the Engelmann spruce beetle in Colorado. USDA Circ. No. 944. 35 pp.
- McCambridge, W.F. 1971. Temperature limits of flight of the mountain pine beetle, Dendroctonus ponderosae. *Ann. Entomol. Soc. Am.* 64: 534-5.
- McCambridge, W.F. 1974. Influence of low temperatures on attack, oviposition, and larval development of mountain pine beetle, Dendroctonus ponderosae (Coleoptera:Scolytidae). *Can. Entomol.* 106:979-84.
- Myers, Clifford A. 1964. Volume tables and point sampling factors for ponderosa pine in the Black Hills. USDA for. Serv. Res. Pap. RM-8, 16 pp.
- Schmid, J. M. 1968. Three insect predators of Dendroctonus ponderosae Hopkins, Ph.D. dissertation, Univ. Michigan, Ann Arbor. 180 pp.
- Schmid, J. M. 1970. Enoclerus sphegeus (Coleoptera:Cleridae), a predator of Dendroctonus ponderosa (Coleoptera:Scolytidae) in the Black Hills. *Can. Entomol.* 102:969-77.
- Schmid, J. M. 1971. Medetera aldrichii (Diptera:Dolichopodidae) in the Black Hills. *Can. Entomol.* 103:849-53.

Terrell, T. T. 1954. Mortality of the Englemann spruce beetle brood during the winter of 1953-1954. USDA For. Serv. Res. Note. IM-10. 9 pp.

Thompson, Gregory R. 1975. Review of mountain pine beetle and other forest insects active in the Black Hills - 1895-1974. USDA For. Serv. Rocky Mtn. Region Spec. Rept. R2-75-1. 25 pp.